Planning Commission Workshop Agenda

CITY HALL
CONFERENCE ROOM 2A
AUGUST 4, 2011
6:00 P.M.

I. CALL TO ORDER

II. ROLL CALL

III. ITEM

ZTA09-01: A request by the City of Glendale Planning Commission to amend Article 7 General Development Standards. The proposed changes, if adopted, would amend sections of the zoning ordinance pertaining to Freeway Billboard Signs. Staff contact: Thomas Ritz, AICP, Senior Planner (City-Wide).

IV. OTHER BUSINESS

V. ADJOURNMENT

FOR SPECIAL ACCOMMODATIONS

Please contact Diana Figueroa at (623) 930-2808 or dfigueroa@glendaleaz.com at least three working days prior to the meeting if you require special accommodations due to a disability. Hearing impaired persons should call (623) 930-2197.

Planning Commission Workshop Staff Report

DATE:	August 4, 2011	**AGENDA ITEM:** 1
TO:	Planning Commission	
FROM:	Tabitha Perry, Principal Planner	
PRESENTED BY:	Thomas Ritz, AICP, Senior Planner	
SUBJECT:	**ZONING ORDINANCE TEXT AMENDMENT ZTA09-01: ZONING ORDINANCE UPDATE - CITYWIDE**	
REQUEST:	A request by the City of Glendale to amend the Zoning Ordinance to allow Freeway Billboard Signs (FBS).	
REQUIRED ACTION:	Review the request in preparation for a public hearing to be held on August 4, 2011. This item is for information only. No Planning Commission action is required at the workshop. The Zoning Ordinance Text Amendment was initiated by the Planning Commission at its January 15, 2009 Workshop.	
PREVIOUS ACTION:	On June 2, 2011, the Planning Commission voted to recommend approval of ZTA09-01 with the exception of the section regarding FBS. This item was continued for discussion at a future Planning Commission Workshop and consideration at a future Planning Commission meeting.	
SUMMARY:	This is a request to amend the Zoning Ordinance. Discussion is focused on amending the Zoning Ordinance to permit FBS. At their June 2, 2011 Planning Commission Public Hearing, the Planning Commission directed that the item be brought back for additional discussion at a future Planning Commission Workshop.	

DETAILS OF REQUEST:

The proposed changes will result in the amendment of the zoning ordinance to address the placement of FBS.

Property Location and Size:
The Zoning Text Amendment is proposed to apply city-wide, with FBS limited to Planned Area Development districts along the Loop 101, Loop 303, and Northern Parkway.

Findings:

- This is a focused request, proposing an amendment which addresses a specific issue which continues to be of highest concern.
- The proposed zoning ordinance amendment will demonstrate staff's responsiveness to the issue.

Analysis:

- By providing a new section concerning FBS, the current section that addresses billboards will remain unchanged.
- The new section of FBS ensures that proposed site locations have demonstrated a significant existing investment in the community, and prevent placement on small sites which could negatively impact neighboring residential areas.
- In response to concerns raised by Planning Commission, staff is enclosing information developed by the billboard industry which indicates that billboards are not a distraction to motorists and do not pose a safety hazard.

ATTACHMENTS:
1. Draft of Proposed Zoning Ordinance Amendment concerning FBS.
2. Maps of potential FBS locations along the Loop 101.
3. Articles concerning sign safety.

PROJECT MANAGER: Thomas Ritz, AICP, Senior Planner (623) 930-2588
tritz@glendaleaz.com

REVIEWED BY:

Jon M. Froke

Planning Director

Jim Colson

Deputy City Manager

TR/df

Zoning Text Amendment Application ZTA09-01: Zoning Ordinance Update

Draft of Proposed Zoning Ordinance Amendment for Freeway Billboard Signs Only

July 25, 2011
Glendale, Arizona

The text amendments (**additions in bold text,** *deletions in italics*) are as follows:

Add to Section 2.300 Definitions:

> **Sign, Freeway Billboard: An identification sign, or a sign which is intended to advertise a business, commodity, service, entertainment, product, or attraction sold, offered, or existing on or elsewhere than on the property where the sign is located and intended to be viewed primarily from SR 101, SR 303, or Northern Parkway.**

...

Section 7.103 - Signs Prohibited Signs should be amended to read:

> 7.103.F. Signs with intermittent or flashing illumination, **except Freeway Billboard Signs,** and animated or moving signs.

...

Section 7.100 – Signs should be amended by adding a new Section 7.110:

7.110 Freeway Billboard Signs

A. **Freeway Billboard Signs (FBS) are permitted in certain zoning districts subject to the regulations noted below.**

   1. **Placing a Freeway Billboard Sign requires the lot to have a minimum of one thousand (1,000) feet of lineal frontage adjacent to one of the following:**

      a. **SR 101 (Agua Fria Freeway)**
      b. **SR 303 (Bob Stump Memorial Parkway)**
      c. **Northern Parkway**

   2. **Placing a Freeway Billboard Sign on a lot requires a minimum of 125,000 square feet of non–residential building area which has received a Certificate of Occupancy on the lot.**

   3. **The zoning of the lot on which the Freeway Billboard Sign is located must be Planned Area Development (PAD).**

4. **One Freeway Billboard Sign is allowed for every six hundred sixty (660) lineal feet of freeway frontage on each side of the freeway.**

5. **The Freeway Billboard Sign must be located within three hundred (330) feet of the freeway right-of-way.**

6. **There shall be a minimum distance of six hundred sixty (660) feet between all Freeway Billboard Signs on any single lot.**

7. **All Freeway Billboard Signs must be set back a minimum of three hundred thirty (330) feet from the property line of any adjacent property having frontage on one of the routes listed in section 7.110.A.1.**

8. **Maximum sign height, including any supporting structures, for a Freeway Billboard Sign must be no more than eighty (80) feet.**

9. **Maximum Freeway Billboard Sign width must be no more than fifty (50) feet.**

10. **Maximum Freeway Billboard Sign area must not exceed six hundred sixty five (675) square feet.**

11. **The message or image of the Freeway Billboard Sign may be static or change at specific or programmed time intervals. The change in message or images shall occur no more frequently than once every eight (8) seconds and shall not have fade or dissolve transitions, or full animation or video, or similar subtle transitions or frame effects that have the appearance of moving text or images.**

12. **Provisions in this section supplement and do not supersede provisions of any PAD in existence before the effective date of this ordinance.**

13. **Design Review approval is required to allow any Freeway Billboard Sign, including those within any PAD in existence before the effective date of this ordinance.**

14. **Any application for development or construction of a Freeway Billboard Sign shall submit a Federal Aviation Form 7460-1 to the local Federal Aviation Administration office for review. A positive recommendation from the Federal Aviation Administration stating the Freeway Billboard Sign has no negative effect on any airport or**

navigational airspace must be received prior to Design Review approval.

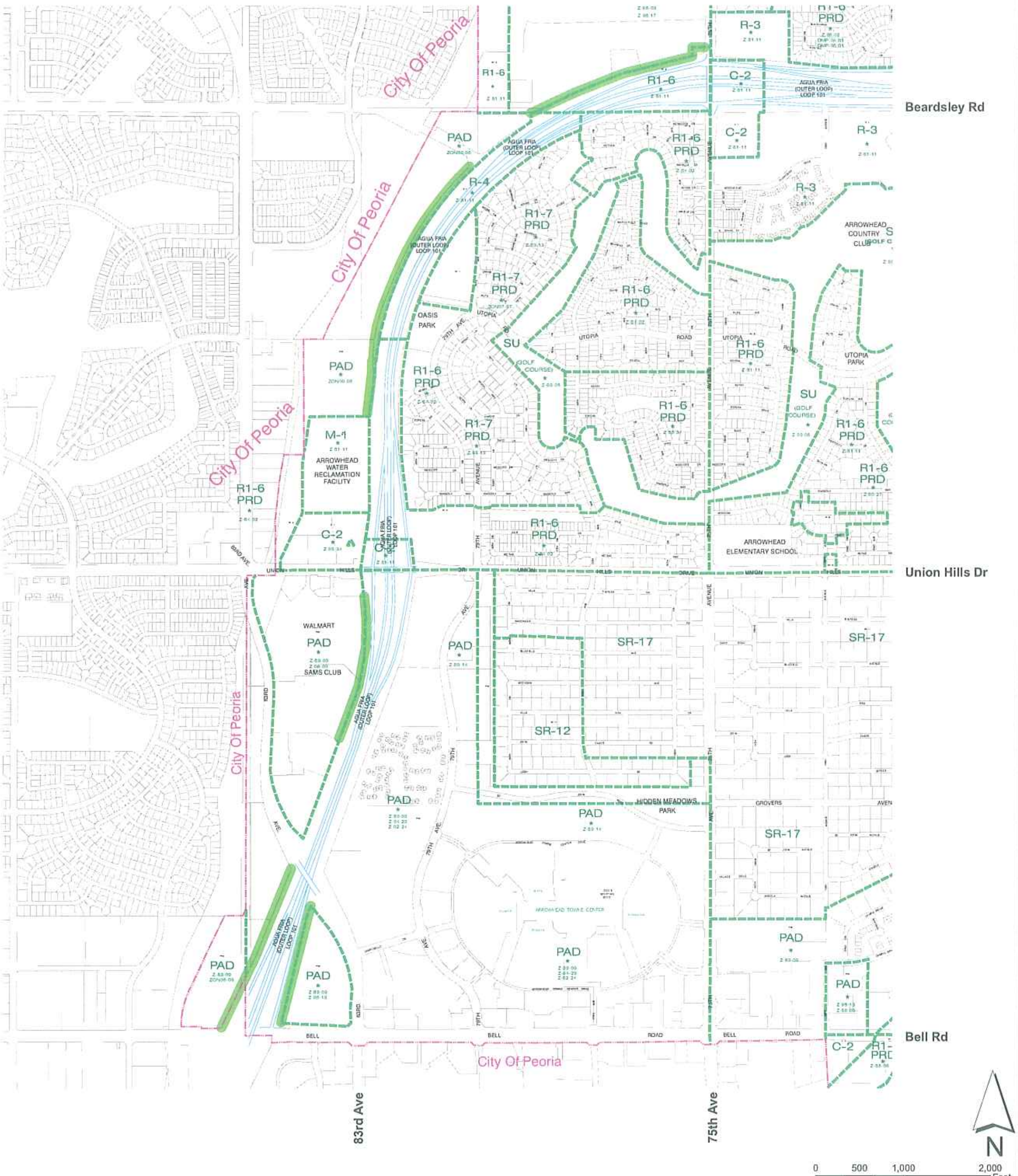
15. **The Glendale Municipal Airport Manager and Luke Air Force Base shall be informed of all requests for Freeway Billboard Sign. The Airport Manager and a representative of the Base shall both state that the Freeway Billboard Sign has no impact on facility operations prior to Design Review approval.**

16. **The minimum setback standard of Section 7.110.A.7 may be reduced by the Zoning Administrator upon a showing by the property owner that strict application of the standard to a specific sign installation will cause a potential hazard to motorist safety due to visibility limitations caused by:**

    a. **Existing or proposed structures; or**
    b. **Grade or elevation changes at or near the subject property; or**
    c. **Proximity to existing or proposed bridges, overpasses or other similar roadway features; or**
    d. **Curvature or other design feature of the adjacent freeway.**

Freeway Billboard Signs

LOOP 101 (North)



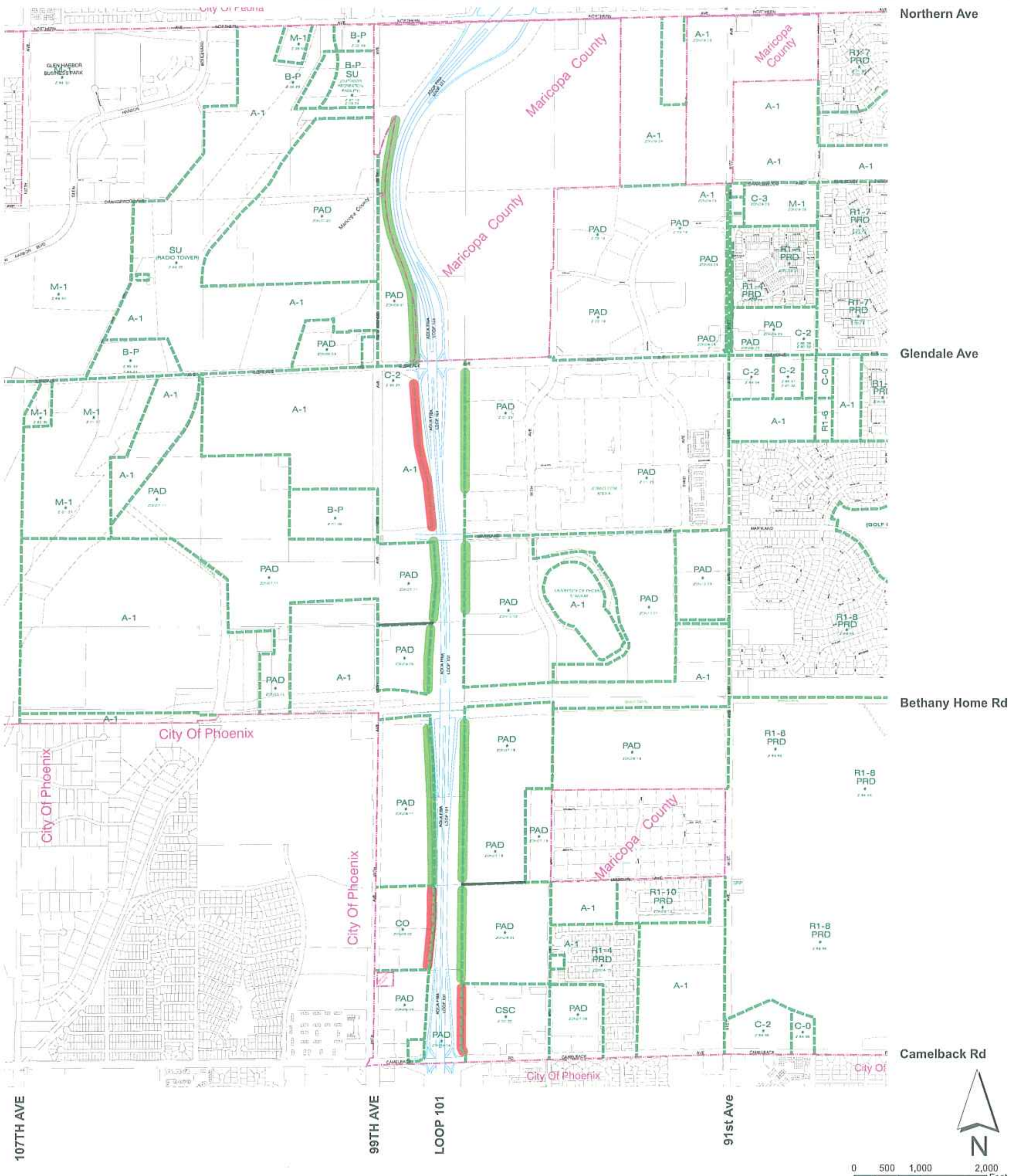
LEGEND

LOT HAS 1,000 FEET OF LINEAR FRONTAGE, IS ZONED PAD AND IS NOT ENTIRELY RESIDENTIAL USES

Prepared By City of Glendale Planning Department: July 2011

Freeway Billboard Signs

LOOP 101 (South)



LEGEND

LOT HAS 1,000 FEET OF LINEAR FRONTAGE, IS ZONED PAD AND IS NOT ENTIRELY RESIDENTIAL USES.

LOT HAS 1,000 FEET OF LINEAR FRONTAGE AND IS NOT ZONED PAD (REZONE WOULD BE REQUIRED)

Prepared By City of Glendale Planning Department: July 2011

Research Review Of Potential Safety Effects Of Electronic Billboards On Driver Attention And Distraction

2 Literature Review

The literature review researched two types of information to understand the safety implications of electronic billboards. One research effort examined current state practices in the regulation of EBBs to determine, for example, the features of those displays at which the regulation is directed and the consistency of regulation among the states. The other type of information was derived mostly from research studies that had the objective of understanding driver behavior in the presence of electronic billboards and/or tri-vision signs. Information of the latter type can provide a source for informed state planning.

The review begins with a description of electronic billboards, tri-vision signs, and a discussion of the relationship of these two display types to changeable message signs used for transmitting roadway status information. The next section describes the results of the review of current state practices on billboard regulation and this is followed by the review of research studies.

2.1 Types of Electronic Billboards

Technology has advanced sufficiently for billboards to provide dynamic and realistic views much like color television. The advanced EBB has the capability to present multiple views and objects that have realistic motion. In contrast, tri-vision signs provide one of three views with rotating cylinders and generate mechanical motion or movement. Since both the EBB and tri-vision sign incorporate components that display motion, some of the issues associated with EBBs are also associated with tri-vision signs. These two types will be compared in functional terms.

For the purpose of the present report, the definition of an EBB is a programmable display that has the capability to present a large amount of text and/or symbolic imagery. Some EBBs present images in realistic motion and in a large variety of colors. The tri-vision sign is defined as a display device capable of presenting three separate images sequentially by rotating triangular cylinders. Appendix A shows examples of EBBs and a tri-vision sign.

The EBB consists of several visual characteristics. EBBs present high-resolution color images, complex visual arrangements, rich variation in color, and a vast amount of images. Operational characteristics include electric power and remote control though a computer terminal. The EBB screen display elements are typically arranged in a matrix. The shape of the EBB is usually rectangular, but irregular shapes are possible. An example is the EBB on the NASDAQ Marketsite's Tower in New York City's Times Square. This EEB wraps around the corner of the building.(1) The NASDAQ video screen is eight stories high and covers 10,736 square ft with light-emitting diodes (LEDs).

The EBB can vary in complexity. Whereas some EBBs display motion, fine detail, and a rich variety of color, other EBBs provide a simpler image. This image is often composed of a short sequence of words in which each letter is defined by a small number of matrix elements such as a 4x6 matrix or a 5x7 matrix. The elements are typically light emitting (i.e., LEDs or incandescent) and presented against a dark background. This simpler version of the EBB shares features of the display used by governmental agencies for presenting information to drivers. This display is referred to as a changeable message sign (CMS) in this paper. The CMS typically employs a matrix technology to provide variable messages displays. Other equivalent terms currently used for this sign are variable message sign (VMS) and, to a lesser extent, dynamic message sign (DMS). The permanent CMS is found mounted above the roadway whereas a portable CMS is usually mobile and is located on the shoulder of the roadway.

Whereas the EBB can display a vast number of images, the tri-vision sign is more limited. The typical tri-vision sign is composed of a series of vertical or horizontal cylinders each of which has a triangular cross section. Each partial rotation of the group of triangular cylinders produces a different image. A single tri-vision sign typically displays, at any given time, one of three images. Although the final composite image does not provide motion, there is still movement due to the transition from one image to another as the cylinders rotate. This movement can act as an attention-getting feature that attracts the driver's attention to the display. One such feature present during the rotation is the partial viewing of two images in transition, where one image advances as the other retreats. Another feature is the change in reflective qualities among the different sides of the triangular cylinders during the transition.

2.2 State Regulations and Policies on Electronic Billboards

2.2.1 Introduction

This section of the literature review pertains to the regulation of EBBs across the United States. A review of existing states' regulations and policies is presented first since it is believed that this will provide the reader with an understanding of how EBBs fit into various states' outdoor advertising policies. Each state's regulations generally derive from the 1965 Highway Beautification Act (HBA). A detailed history and overview of the federal outdoor advertising control program, which includes the HBA, can be found on the FHWA's ORES web site: http://www.fhwa.dot.gov/realestate/oacprog.htm. A review of state outdoor advertising regulations revealed that common billboard guidelines governing EBBs and tri-vision signs do not exist. While states generally have consistent regulations governing static billboards, regulations covering EBBs and tri-vision signs vary widely. Implementation practices differ significantly from state to state. A broad spectrum of regulations exists, ranging from lenient control to the prohibition of outdoor advertising.

2.2.2 Sources of Information

Federal and state Department of Transportation (DOT) personnel provided information regarding state regulations and policies. The information pertained to whether states regulate EBBs, and if so, in what manner. The sources of information are described briefly as follows:

- **State Outdoor Advertising Regulations.** Efforts were made to obtain the most current billboard regulations nationwide. These regulations were collected from various sources, such as the state DOT directly, a state's website, or from the National Alliance of Highway Beautification Agencies' (NAHBA) website. Overall, regulations were obtained from 44 states.
- **Personal Communication.** In addition to obtaining state documents, the researchers contacted states and FHWA division offices. Since a supporting contractor was to be directly contacting state DOTs, an introductory e-mail message was sent from FHWA Headquarters to each Division Office to notify the FHWA Division Office and the state DOTs of the contractor's role. The FHWA contractor contacted state personnel who were knowledgeable of their state's billboard regulations. The telephone calls were of an unstructured nature, and their purpose was to determine if local constituents had submitted comments or complaints about EBBs, and if research had been conducted on EBBs in the state.

FHWA Division Offices. Nine FHWA Division Offices were contacted. FHWA's ORES recommended some of the selected Division Offices and others were selected randomly.

State DOTs. Some state DOT personnel were contacted at the suggestion of their local FHWA Division Office while other states were selected randomly. Ten state DOTs were contacted by telephone.

National Alliance of Highway Beautification Agencies (NAHBA). In the early 1990s, a group of individuals responsible for directing or managing their state's outdoor advertising program formed the NAHBA. The Alliance meets regularly to discuss new developments in technology, upcoming legislation, and ways to improve or streamline regulation of outdoor advertising, junkyards, landscaping, and visitor centers. Additionally, NAHBA maintains a website that contains outdoor advertising regulations of numerous states and the federal government.

A NAHBA meeting was held in Washington, D.C., in late January 2001. Two members of the research team and their FHWA contracting officer technical representative met with NAHBA members after the formal meeting had ended. Representatives of Florida, Kentucky, Missouri, Oklahoma, and Utah were present. The meeting served a purpose similar to the telephone calls, except that it allowed a more interactive conversation in more detail.

NAHBA provided the responses from an informal email questionnaire pertaining to EBBs and a tri-vision sign survey to the research team. These are presented in a subsequent section of this report.

2.2.3 *State Regulations and Practices*

In a July 1996 memorandum to FHWA Regional Administrators, the ORES provided additional interpretation of advertising technology to the individual states regarding off-premise changeable message signs. An off-premise sign is a sign that disseminates information that **does not** directly relate to the use of the property on which the sign is located. ("Changeable message signs are acceptable for off-premise signs regardless of the type of technology used, if the interpretation of the State/Federal agreement allows such signs," page 1, paragraph 2, sentence 4 of the memorandum).

In a July 1998 memorandum, the ORES reaffirmed their policy that off-premise signs using animated or scrolling displays that are dependent on flashing, intermittent, or moving lights were not conforming signs. This decision was made after careful review of a videotape showing the full-motion EBB erected in Scottsbluff, Nebraska. It was concluded that such signs raise "significant highway safety questions because of the potential to be extremely bright, rapidly changing, and distracting to motorists," (page 1, paragraph 4, sentence 1 of the memorandum).

A majority of states have a policy regarding the lighting of billboards, and through this policy, states regulate EBBs. While common themes are present in most lighting regulations, each state's laws have unique wording. As an example, the Arkansas State Highway and Transportation Department's Outdoor Advertising Policy,[(2)] Regulations for Control of Outdoor Advertising on Arkansas Highways, as authorized by Arkansas Act 640 of 1967 and Highway Commission Minute Order No. 77-6, section III, subsection D, Lighting states:

A. Lighting Signs may be illuminated, subject to the following restrictions:

1. Signs, which contain, include, or are illuminated by any flashing, intermittent, or moving light or lights are prohibited, except those giving public service information such as time, date, temperature, weather, or similar information.
2. Signs which are not effectively shielded as to prevent beams or rays of light from being directed at any portion of the traveled ways of the Interstate or Primary highways and which are of such intensity or brilliance as to cause glare or to impair the vision of the driver of any motor vehicle, or which otherwise interferes with any driver's operation of a motor vehicle are prohibited.
3. No sign shall be so illuminated that it interferes with the effectiveness of, or obscures an official traffic sign, device, or signal.

2.2.4 *National Alliance of Highway Beautification Agencies*

Tri-vision Sign Survey. A 1999 survey sponsored by and presented at the annual NAHBA conference reviewed the tri-vision sign advertising regulations of every state and Washington, DC. The following results show that a majority of states are addressing current advertising technologies in their outdoor advertising regulations. At the time of the survey:

- Nine states had specific regulations governing signs,
- Nine states had regulations on tri-vision signs that were either being drafted or in pending legislation,
- Fifteen states had regulations regarding moving parts and/or lights,
- Nine state had no regulations on tri-vision sign, and
- Six states as well as Washington, DC, prohibited tri-vision signs.

Table 1 provides a summary of tri-vision sign exposure dwell times and transition times that were presented in the 1999 NAHBA survey.

Table 1. Timing Boundaries of Several Tri-Vision Sign Policies.

Timing Boundaries	Average	Maximum	Minimum
Minimum Exposure Dwell Time (sec) [1]	7.32	10	4
Maximum Transition Twirl Time (sec) [2]	2.16	4	1

Source: NAHBA 1999 Conference.

1. *Minimum Exposure Dwell Time:* For billboards that change messages, (e.g., tri-vision sign or CMSs), the exposure time can be defined as the minimum amount of time, in seconds, that a message must be shown. Some minimum exposure times have been derived from analytical calculations (based on speed limit and the number of faces of a billboard that can be seen) while other minimum exposure times have come in the form of recommendations from outdoor advertising suppliers or have been based upon engineering judgment.
2. *Maximum Transition Twirl Time:* The transition time is the amount of time, in seconds, that is required for a billboard (such as and EBB or tri-vision sign) to automatically change messages. Many states have set a maximum transition time for this change. The maximum was originally determined by taking into account the mechanical constraints of older tri-vision signs and attempting to limit the amount of visual distraction caused by a sign's transition. Due to advances in technology, transitions executed by a full-motion video billboard are virtually instantaneous.

Electronic Sign Data. In early February 2001, NAHBA asked its membership to answer four questions regarding EBBs. One question relevant to this research is: "Do you have a definition of an electronic sign?" Of the 20 responses that were received, five states had a definition, 14 did not have a definition, and one state was in the process of rewriting its definition.

2.2.5 *State Outdoor Advertising Regulations*

A review of statutes was conducted to identify state prohibitions on specific characteristics of signs. This review is presented in Appendices B and C. The results indicate, in part, that of 42 states:

- Thirty-six states had prohibitions on signs with red, flashing, intermittent, or moving lights,
- Twenty-nine states prohibited signs that were so illuminated as to obscure or interfere with traffic control devices, and
- Twenty-nine states prohibited signs located on interstate or primary highway outside of the zoning authority of incorporated cities within 500 ft of an interchange or intersection at grade or safety roadside area.

Additional information on other sign characteristics includes insufficient shielding of light, timing limits, and sign location relative to traffic control devices.

2.2.6 *Concerns about Electronic Billboards*

Numerous states have attempted to identify a relationship between EBBs and safety by using traffic conditions as a surrogate measure. The states of Nevada, Utah, Texas, New York, New Hampshire, and Massachusetts reported no evidence of increased traffic safety problems after the installation of electronic information displays in their city centers and along their highways. Additionally, five state DOT personnel were asked if a crash relationship with EBBs existed in their states; the responses were that a relationship between crashes and EBBs was not identifiable. However, one belief is that EBBs are typically on congested roadways where drivers have time to look at the sign, so it is difficult to determine if the EBBs cause crashes, let alone traffic congestion.

2.3 Reports on Billboards and Safety

Determining the effect of roadway commercial advertising billboards on safety is a difficult endeavor for several theoretical and methodological reasons. First, crash frequency is often used as a measure of safety, yet crashes occur relatively infrequently, so changes in frequency may be subtle and are not easily attributed to particular factors. In addition, distraction effects may interact with other factors, such as weather. Furthermore, crash reporting procedures differ across jurisdictions and may not refer to billboard distraction as a factor in the crash. Additionally, drivers may be unlikely to identify distraction as the cause of a crash for liability reasons. Regardless of these difficulties, researchers have examined the effects of billboards on safety. The results are mixed and inconclusive, as shown below.

2.3.1 *The Wachtel and Netherton Report*

The safety and aesthetics of commercial electronic variable message signing were reviewed by the FHWA in 1980 (3) and are summarized below. Part of that effort included a review of published studies on the safety effect of roadside advertising signs, including several field and laboratory studies from 1951 to 1978 on non-electronic advertising billboards, and one analysis in 1976 of an electronic advertising sign in Boston.

The Minnesota Department of Highways concluded from a field study in 1951 that an increase in commercial billboards would result in an increased crash rate. A 1951 field study conducted by Iowa State College concluded that more crashes caused by driver inattention occurred on road segments that contained billboards. The Michigan State Highway Department in 1952 found that advertising signs did not correlate with the roadway's crash experience, except for illuminated (neon) signs, which did correlate with an increased crash rate. A 1961 study of California Route 40 concluded that road segments with billboards experienced significantly more crashes than segments without billboards. A 1967 field study compared the crash history of three locations in Chicago before and after the installation of three illuminated, commercial changeable message signs. Crash rates did not change at two of the sign locations, but the third sign location showed an increase of crashes. The third sign had alternating lights, showed several advertising messages, and was illuminated by bright white lights. The rapid increase in crashes led state highway officials to request that blue lights replace the white lights.(3)

The Tele-Spot sign in Boston was an off-premise commercial electronic sign. The sign was visible from the Central Artery in the midst of complex on- and off-ramps, regulatory signs, and guide signing. The Massachusetts Outdoor Advertising Board conducted an analysis of traffic crashes three years before and two and a quarter years after sign installation. The analysis showed an overall reduction in the Average Daily Traffic (ADT) and crashes along the expressway, but on the areas of the expressway from where the Tele-Spot was visible, the crash reduction was 10 percent less than the overall reduction. The Board regarded the 10-percent difference as an indication that the Tele-Spot sign was a distraction and a safety risk, and consequently revoked the license for the sign.(3)

2.3.2 Wisconsin DOT Report

The Wisconsin DOT examined the crash rates on Interstate 94 eastbound and westbound adjacent to the Milwaukee County Stadium(4). The analysis compared the crash rates three years before and three years after the installation of a variable message advertising sign. The sign, installed April 13, 1984, displayed sporting scores and advertisements, and changed images an average of 12 frames per minute. The purpose of the comparison was to assess whether the presence of the sign correlated with a change in the crash history of I-94. To determine crash rate, the Wisconsin DOT inventoried crashes that occurred on the segment on I-94 from where the sign was visible, categorized them into side-swipe and rear-end crashes, and determined the ADT from an automatic traffic recorder. The crash rate was derived from the equation:

crash rate per million vehicle miles = crash frequency/(length of segment) *ADT *10^6)

Eastbound Segment. The crash rate for the three years before installation was 3.12 crashes per million vehicle miles traveled (VMT). The three-year crash rate after installation was 4.25 crashes per million VMT. The increase in crash rate after installation was 1.13 crashes per million VMT, or 36 percent. Specifically, the rate of increase for sideswipe crashes was 8 percent, and the rate of increase was 21 percent for rear-end crashes.

Westbound Segment. The crash rate before installation was 2.91 crashes per million VMT, and 3.53 per million VMT after installation, an increase of 0.62 crashes per million VMT or 21 percent. The rate of increase was 35 percent for both sideswipe crashes and rear-end crashes.

The Wisconsin DOT concluded from its analysis that the variable message sign had an effect on traffic safety, notably an increase in the rate of sideswipe crashes. In addition, the report concluded that the greater increase in crashes for the eastbound segment was due to the orientation of the sign towards eastbound traffic. (This sign was removed 16 years after it had been installed, when the Milwaukee County Stadium was demolished. A similar sign was installed on the new stadium.)

2.3.3 The Curriden Article

A recent court case in Texas arose from a crash in an airport caused by a driver reading an electronic sign that listed departure and arrival times, and gate information. The driver stopped his vehicle to read information on the sign. A second vehicle swerved around the stopped vehicle and side swiped a vehicle in the adjacent lane, resulting in a three-vehicle crash. Two drivers were injured in the crash and sued the airline that owned the EBB. A jury found that the EBB was the indirect cause of a multiple vehicle crash at the airport and returned a negligence verdict against the airline. The airport subsequently removed the EBB.(5)

2.4 Potential Safety Factors

2.4.1 Distraction

The review of crashes presented previously suggests that EBBs may be associated with a higher crash rate under certain conditions. If this possibility is verified through further research, then it can be asked whether these crashes are a result of driver distraction in which the distracting stimulus is the EBB.

Distraction can be a framework in which to view EBBs and safety. The safety consequences of distraction from the driving task can be profound. Treat et al.(6) found that driver inattention and improper lookout increase the likelihood of crash occurrence and are major factors underlying the causes of crashes. According to Wang, et al.,(7) an analysis conducted by the National Highway Traffic Safety Administration (NHTSA) of causal factors of crashes showed that distraction by sources external to the vehicle accounted for 3.2 percent of the crashes. The external sources included people, events, and non-specified objects. The NHTSA analysis did not identify the external objects, nor did it identify billboards as among the sources of distraction. However, the data suggest that, on occasion, external stimuli can be sufficiently distracting to drivers, causing or resulting in a crash.

Distracting Stimuli. One type of distracting stimulus is the unexpected event that results in an involuntary reaction. This type of stimulus is unanticipated and produces a surprise or orienting response - the person will redirect his or her attention to the new event to identify it and assess its significance. Such a stimulus may be an event that is not typical for that time or place, e.g., a flash of light, movement or sound.

A more subtle form of distracting stimulus can be one in which the stimulus has a less surprising quality, and thus presents more time for the driver to decide whether to attend to the stimulus and how much attention to direct to the stimulus. Dorneim(8) documented that this has been has been a problem for pilots. In some situations, a pilot will occasionally attend more to a secondary task and neglect the primary task of flying the plane, sometimes resulting in a crash. Although the task of flying is obviously different from driving, there may be lessons to be learned for drivers. NASA is currently conducting research on ways to avoid this type of air crash. It may prove useful to check the progress of this research to see whether NASA research results have implications for driver distraction. Some of the research questions involve understanding how people know when to return their attention to a task, as well as identifying the limits of switching between tasks.

Measures of Distraction. For this project, driver distraction is characterized as deterioration in driving performance, the primary task, while attending to a second, non-driving task. The second task is subordinate to the driving task. An example of a non-driving task is operating an audiocassette system or using a cellular telephone. When the safe operation of the vehicle is degraded by the performance of the second task, the second task is defined as a "distractor."

Safe operation or control of the vehicle is recorded with measures of effectiveness (MOE) for driving. These measures include lateral deviation of the vehicle and maintenance of appropriate speed, as indicated by headway measures. Lack of control indicated by excessive lateral deviation or inappropriate speed could result from distraction, sleepiness, inability to see the road because of weather or lighting, poor perception of road geometry requirements, or other reasons. Since there are multiple factors that can contribute to lack of vehicle control, the design of a distraction study must take into account these other factors and ensure that they do not confound the design and allow misinterpretation of the data.

Lateral deviation can be measured by analysis of variability in steering wheel position, and/or varying distance of the vehicle from a lane marking on the road. When measuring lateral deviation, a certain amount of variability in deviation is expected. Greater-than-normal lateral variation may indicate a degree of lack of vehicle control. An example of lateral deviation occurs during the performance of a non-driving task such as the selection, orientation, and insertion of an audiocassette into the cassette player while performing the primary task of negotiating a curve. If the cassette operation is performed in the same manner and at the same rate as when the vehicle is motionless, there is a high likelihood of lateral deviation. This scenario of cassette operation would be an example of a distracting task.

Another measure of safe vehicle control is the maintenance of appropriate speed. One driving behavior that would lead to improper speed is the selection of a more or less constant speed (speed invariance) when nearby vehicles change speed. This could result in an unsafe headway condition. Lack of safe control due to improper speed selection could be due to reasons similar to those listed above for lateral deviation. Another behavior measured by speed is the slowing of a vehicle to view an item external to the vehicle. Braking for emergencies may also be considered for a measure of distraction.

2.4.2 *Conspicuity of Displays*

To what degree does an external, conspicuous stimulus unrelated to driving distract a driver from the driving task? This question is basic to the notion that a billboard may degrade driving performance by diverting attention away from the driving task. If a billboard degrades driving performance, it may be useful to identify the components of the billboard that can distract drivers. Some possible distracting components of a display are motion, complexity, and illumination. If such qualities are relevant to distraction, do they act alone or do they interact with each other? To the extent that these qualities are identifiable, it may be possible to understand their effect on distraction.

A brief review conducted by Hughes and Cole[9] identified the physical properties of a conspicuous object. Important properties that contribute to conspicuity include object size, object contrast with its immediate background as well as the complexity of the background. An additional property is "the boldness of the graphics used to display a message."

According to Cole and Hughes,[10] conspicuity consists of two types: attention conspicuity and search conspicuity. Attention conspicuity is the ". . .capacity of an object to attract attention, and. . .might be measured by the probability of the object being noticed when the observer has not had his or her attention directed to its likely occurrence." Search conspicuity is ". . .the property of an object that enables it to be quickly and reliably located by search." Cole and Hughes suggest that eye movement that is responding to a stimulus in the peripheral visual field can be used to infer attention conspicuity in the visual mode. Such movement may be a "quasi-reflex eye movement that is related to human defense reaction."[10]

Theeuwes[11] challenged the view that conspicuous objects attract attention automatically. Instead, drivers will attend to the driving task and not a distractor. His past research showed that subjects ignored salient objects that were irrelevant to a search task. In a subsequent study, participants were instructed to locate a task-related stimulus (a blue sign) in a video taken from the driver's perspective. Distracting stimuli (e.g., a pedestrian in an orange jacket) were present in some experimental conditions, but not others. The results indicated that when the target stimulus, or blue sign, was in an expected location, the presence of the distractor had no impact. However, when the target was in an unexpected location, thus increasing the search time, the presence of the distractor increased the time required to locate the target above that due to expectation effects.

The visual environment affects the conspicuity of objects. Since drivers obtain travel related information by searching the visual environment for a target, such as a street sign, outdoor advertising can compete with targets of driving-related information. The concept of "visual noise" refers to non-target objects in an environment and can be used to determine a sign's conspicuity in a particular environment. Akagi et al.[12] state that "Objects causing visual noise can be defined as objects that hinder drivers' field of view, such as billboards and buildings along roadsides." This study reported that increases in the visual noise (i.e., the number of signs in a roadway location) correlated with longer search time required for drivers to locate a target sign.

In a study performed by Hughes and Cole[9] regarding the conspicuity of roadside objects, drivers reported "all the objects or things that attracted their attention" as they drove through 20 km of residential streets and arterial roads. Afterwards, they observed a film of the same route, taken from the driver viewpoint. Advertising displays accounted for 13.7 percent of reports in the driving study and 10.2 percent in the laboratory study. Driving related objects (road, traffic control devices (TCDs), vehicles, and people) accounted for 51.4 percent of reports in the driving task and 57.9 percent in the laboratory study. Other non-driving task elements included immediate and general roadway surroundings. Advertising elements were reported equally on arterial and shopping center routes, and more so than on residential streets. However, in residential streets, drivers directed more attention to non-driving related elements. This suggested a possible spare attention capacity.

A field study by Luoma[13] analyzed driver eye fixations on roadside advertisements during a 50 km drive in Finland. Results indicated that accurate perception of advertisements was associated with longer fixation times (2.3 sec) than the times for pedestrian markings and speed limit signs (0.4 sec to 0.5 sec). The author concluded, "...long fixation times indicate that the characteristics of roadside advertisements related to information ergonomics are poor."[13] Information ergonomics is the practice of providing information in the most efficient way, such that viewers can access the information quickly and clearly.

Roadway Context. Determining whether billboards influence driver behavior would require understanding the roadway context of a billboard. For example, roadway factors such as the angular distance of a billboard, billboard placement and volume characteristics of an intersection, may influence driver responsiveness to visual stimuli and the experience of workload. In this sense, information on the effect of the roadway context on driving performance should assist in defining appropriate billboard locations. Research on driver search behavior in high and low volume intersections by Rahimi, Briggs and Thorn[14] in 1990, suggests that higher volumes of traffic affect driver eye and head movements. The research indicates that the greater visual complexity associated with the high volume intersection required drivers to search the environment *more* than in the low volume intersections. It can be conjectured that additional visual stimuli, such as billboards, may add additional demand to driver workload in high-volume intersections.

2.4.3 Legibility

One event that can be considered a distraction occurs when a driver passes a sign where the text has poor legibility. The weakness in legibility may be due to poor character font design, improper spacing of letters, or other factors. However, if the information is of sufficient interest, the driver may try to read all of the text anyway. Such a decision could take time away from the driving task thus increasing crash risk. If on the other hand, the sign had text that met legibility standards, less effort would be required to read the sign. Although this situation is a more subtle distraction than that due to perceived motion in a sign, it still could present potential for crash risk. Legibility information is available for CMSs. Although the CMS is restricted to providing roadway related information, its legibility requirements may be relevant to the design of the simpler EBB

Luminance and Luminous Contrast. Garvey and Mace[15] examined CMSs to identify the features that contribute to their visibility. Both field and laboratory studies were employed following a review of the literature. Of particular interest in this report are the requirements for lighting, such as the luminance value and contrast ratio necessary for legible viewing. The study discussed requirements for displays such as LEDs, fiber optics, lamps, flip discs, and reflective discs. The authors provide guidelines that are aimed at improving the visibility of all CMSs, regardless of technology.

Minimum luminance values were recommended for CMS visibility. These values are based on the 85th percentile driver accommodated at 198 m (650 ft). Age and position of the sun were two of the most significant factors when determining minimum luminance. Values are presented for drivers in two age ranges (16-40 and 65 or older). When the CMS is backlit (sun behind and above CMS) or under washout conditions (low sun shining directly on CMS), 1000 cd/m^2 is recommended for both age groups. This value accommodates less than 50 percent of older drivers at any luminance level with extreme sun angles. When the sun is directly behind the CMS, few if any people will be able to read the characters under any luminance level. When the sun is overhead the 65 years and over group still requires 1000 cd/m^2, but only 850 cd/m^2 are required for the younger group. During overcast or rain, 600 cd/m^2 is required for the older group and 350 cd/m^2 for the younger. For the nighttime condition, both groups require a luminance of 30 cd/m^2.

According to Garvey and Mace,[15] there should be a minimum luminous contrast between the unlighted and lighted elements on a CMS; a maximum luminous contrast was not provided. Contrast orientation should always be *positive*, that is, the characters should be lighted against a dark or less luminous background. A negative contrast is likely to result in a 25 percent shorter legibility distance.

Contrast luminance for a CMS was determined with the formula:

$$\frac{L_t - L_b}{L_b}$$

where:

L_t = luminance of a character module with all of the elements "on"

L_b = luminance of a character module with all of the elements "off."

The minimum acceptable contrast luminance is 5, and the optimal contrast luminance varies from 5 to 50.

A summary of existing literature on sign visibility performed by Kuhn, Garvey and Pietrucha,[(16)] examined the two main research areas of sign detection; that is, sign conspicuity and sign legibility. The emphasis was on the more familiar and traditional sign rather than electronic signs. It is likely, however, that the design of an electronic sign would benefit from some of this information. A series of visibility guidelines for on-premise signs was presented. (An on-premise sign disseminates information that directly relates to the use of the property on which it is located.) Later research by Kuhn[(17)] compared lighting methods (external illumination, internal illumination with opaque background, internal illumination with translucent background and neon) under day and night conditions to examine sign visibility features.

Claus and Claus[(18)] addressed the issue of startling types of signs, such as those employing "flashing or animation to catch attention." These authors discuss different types of motion or movement. One of these is ". . .jumping arrows, or rapidly chasing or flashing lamp borders. . . (that) should perhaps be limited to midways and to rows of theater marquees." They did allow for other pictorial sequences that may be more acceptable as well as alternating displays such as the time and temperature display.

Alphanumeric Characters and Their Spacing. The design or selection of font type and the spacing between characters (letters), words and sentences are critical in achieving effective legibility of signs, especially when legibility is defined by the distance at which a sign can be read. Garvey & Mace[(15)] provided draft guidelines for the design of the elements and characters that compose a word and word groupings on a CMS, in which the character font is composed of light emitting elements. To achieve effective legibility, a number of features are considered. It is important to address each of the features, since they interact with each other. For example, to design an upper case character font, use a 5 x 7 matrix of light emitting elements. However, with a small matrix of this size, it is well to avoid thickening of a line in a character (e.g., as in an "I" or "T") by adding another row or column of elements because the legibility distance is shortened by about 25 percent.

Font design for exterior signs should be simple without serifs. Additional information was provided on the height of the character, the proportion of the character or width-to-height ratio, and stroke width of the character. Further information was provided on the spacing between letters, between words and between lines of characters. Signs with light emitting elements have special characteristics. Light emitting elements provide high contrast between characters and background and thus provide superior performance over reflective signs at night. However, the light intensity requires careful adjustment. According to Garvey and Mace,[(15)] high contrast produced by lighted elements at night can "create halation or irradiation, blurring letters with wide stroke widths."

Message Length. A series of studies was performed by McNees and Messer[(19)] to evaluate urban freeway guide signing. A study relevant to EBB issues examined the reading time required for guide signs. Study variables included "bits" (i.e., the amount of information on each panel) and number of sign panels. A typical sign panel contained an exit number, exit direction, cardinal direction, route number, and two destinations. It also included symbols such as a shield, and directional arrows. Examples of bits of information were: "I-395," "Washington, D.C." and "South." Each sign panel had, on average, six bits of information. The display time of the sign simulated the total time a driver would have available to read a guide sign in a typical freeway environment. The display times provided for reading the signs represented three traffic conditions: "extreme" (2.5 sec display time), "minimum" (4 sec display time), and "desirable" (6 sec display time). Median reading times for these conditions were: 1.7 sec (extreme), 2.0 sec (minimum), and 2.9 sec (desirable). The results indicated that the time used to read the signs was dependent on quantity of information per sign as well as time available to perform the task. Based on these results, the authors concluded that the information content of a highway guide sign should not exceed six bits of information per panel.

2.5 The Driver

2.5.1 Driver Age

The analysis of distraction should consider the effect of driver age. If a significant portion of the driving population is more susceptible to distraction, then research on the relationship between distraction and safety should recognize this susceptibility. Such research could provide information about age-related differences regarding visual capability or reaction times that are relevant to driver reaction to EBBs. Both older drivers and young/inexperienced drivers are examined in this discussion.

The highway safety community recognizes that the probability of crash involvement varies with driver characteristics, most notably age. Highway data analysis demonstrates that the young driver and older driver populations have high crash involvement, and elevated injury and fatality rates. According to the Transportation Research Board's Special Report Number 229,[20] the high involvement rate of older drivers in crashes is second only to the rates of young drivers

Experience and age *may* be important factors to consider in the evaluation of the effects EBBs have on safety. The research literature provides a firm foundation for stating that age and experience need to be considered. If EBBs are ultimately found to have a high degree of attention conspicuity - that they compel drivers to attend to them - then it is reasonable to expect that populations such as older or inexperienced drivers, who have less attention to spare, will be placed at greater risk by EBBs.

The Older Driver. According to Barr and Eberhard,[21] the safety and mobility of older drivers, generally defined as 65 years of age and above, are highly relevant to transportation planning. Because of an increasingly aged population, the number and proportion of older drivers are rising. By 2020, Waller[22] has estimated that 17 percent (50 million people) of the United States population will consist of people 65 years and older, compared to 12 percent in 1988. The proportion of older adults licensed to drive is increasing. For example, in 1980, 60 percent of older adults (at least age 65) were licensed drivers, compared to 70 percent in 1989. These data point to the need to include older drivers in research programs on roadway safety, including the evaluation of EBBs and distraction.

Older drivers have a high crash risk per mile.[22] They are involved in a disproportionate number of fatal crashes and multi-vehicle crashes where they were the responsible party,[23, 24] and are over-represented in crashes that involve turns, merges, and yielding the right of way.[25]

Recent studies performed by Ball and Owsley[26] point to cognitive demands as influential factors in driving. Visual processing speed and the ability to handle selective and divided attention demands may have the greatest impact on crash rates. An increase in age did not directly contribute to crash involvement. However, an increase in age correlated with lower processing speed and decreased attention. The fact that attention and visual processing speed degrade with age may be symptomatic of the increasing inability of older drivers to encode and process all but the most important information in the driving environment.

The Younger Driver. The young driver (16 to 24 years old) is more likely to be involved in a crash than drivers of other ages, and a driver under 23 years of age is 2.5 times more likely to be killed in a crash than drivers 25 years and older, according to the NHTSA.[27] Whereas the young driver crash risk on a per-mile driven basis is greater than the crash risk of other drivers, their risk decreases on the continuum from 16 to 24 years old, according to Lerner et al.[28]

Incidents involving younger drivers are attributed to age and experience-related factors. Widely recognized age-related factors reported by Decina et al.[29] include risk-taking and alcohol consumption. Experience-related factors include the psychomotor, perceptual, and cognitive skills required for steering and maintaining speed, driving during high risk periods (such as at night), inefficient or inappropriate scanning behavior, poor hazard recognition, and poor driving judgment and decision-making.

The young driver demonstrates poorer coordination of separate driving tasks and tends to concentrate on one aspect of performance, such as maintaining lane position.[29] According to Mournat et al.,[30] the visual scanning behavior of a young driver is less effective than that of mature drivers because the young driver tends to focus more closely in front of the vehicle. Furthermore, Miltenburg and Kuiken[31] report that the inexperienced driver is likely to have attention drawn to irrelevant but "attention-getting" objects. The aforementioned research suggests that the young driver may be more vulnerable to distractions than the more mature driver. The data indicate that the young driver has weak situational awareness and relatively poor focus on the driving task itself. Thus, distracting stimuli, inside or external to the vehicle, may adversely affect the young driver.

2.5.2 Driver Familiarity with Route

Commuters and visitors require different information while traveling. The familiar driver requires more information on traffic conditions and incidents, whereas the visitor requires more navigational and guidance information. A field study of driver visual search and scan patterns performed by Mourant et al.[30] showed that drivers' visual fixations on traffic, road and lane markers, and bridges and road signs decreased as the drivers became more familiar with the routes. One conclusion from these data is that drivers who are familiar with a roadway may be less likely to attend to familiar signs, including EBBs. Thus, differences between visitors and commuters in visual attention to commercial signs may be a relevant variable in assessment of distraction effects of EBBs since more eye-catching displays may be needed to attract the commuter.

2.6 Measures of Effectiveness

2.6.1 Surrogates

Commercial EBBs are designed to "catch the eye" of drivers. Their presence may distract drivers from concentrating on the driving task and the visual surrounds. Research in other areas share a concern about driver distraction and may be applicable to the question of EBBs and driving performance. Investigations of driver distraction and safety have notably focused on two cases: cellular telephone use while driving, and in-vehicle information displays. In each case, the application of a new technology raised concerns about driver distraction. The following sections highlight research in these areas.

Cellular Telephone Use in Vehicles. The number of cellular telephone users reported by Cain and Burris[32] in 1998 was 63 million, and at a growth rate of 40 percent per year, the NHTSA[33] estimates that the number of users will reach 80 million by 2000. The increase in the number of cellular telephone customers, in combination with high-profile crashes involving cellular telephone use, has raised public awareness of the safety aspects of in-vehicle telephone use and led to legislative initiatives aimed at restraining telephone use in vehicles.

Crash Risk Analyses. Redelmeier and Ticshirani[34] performed an epidemiological study of crash risk associated with cellular telephone use linked customer telephone bills to crash records maintained at the New York Collision Reporting Center to identify telephone use at the time of a crash. The study concluded that cellular telephone use quadrupled the risk of a crash during the call. Another epidemiological study performed by Violanti[35] found a 34 percent increase in risk of crash among vehicles with celluar telephones.

Application to EBBs. Using cellular telephones while driving imposes at least three tasks: first, manually manipulating the telephone, which could affect control of the vehicle; second, glancing at the telephone, which requires looking away from the roadway; and third, engaging in conversation, which may disrupt concentration. The relevance of information on cellular telephone use to EBBs lies in visual (glancing) and cognitive (mental engagement) behaviors. Viewing EBBs or using a telephone requires drivers to look away from the roadway for some period. Similarly, reading a sign could disrupt a driver's concentration, just as engaging in a telephone conversation might.

According to Cain and Burris,[32] hands-free telephone use carries about the same risk observed in hand-held use, and a NHTSA report[33] cites that a telephone conversation is a factor in crashes more frequently than dialing. Cain and Burris[33] believe that the type of conversation is significant in determining crash risk, and McKnight and McKnight[36] believe that complex and intense conversations the riskiest and simple conversation relatively risk-free. Thus, becoming mentally preoccupied can be as distracting to a driver as manually operating a telephone or glancing away from the roadway.

In-vehicle Information Systems. Advances in communications technology have enabled the development of electronic devices that display traveler-related information to drivers in transit. Such devices can potentially redirect (or distract) a driver's attention from the primary task of driving. An examination of in-vehicle distractions may contribute to an understanding for potential out-of-vehicle distractions such as EBBs.

The presence of in-vehicle devices that provide traveler-related information, such as turn-by-turn directions, has raised questions regarding the amount of time taken away from the driving task by the information display. One concern is that a driver will underestimate the amount of time required to use the device, take longer than expected, thus taking too much time away from the driving task. This is similar to the concern in which a driver spends too much time looking at a stimulus external to the vehicle.

In order to measure visual distraction associated with the use of in-vehicle devices, a methodological approach was developed based on eye glances. This method calculates the total number and average duration of eye glances required to operate specific in-vehicle devices. Data compiled from research in the late 1980's defined the average time for a single glance and the average number of total glances required to use a variety of devices. Devices were the speedometer, mirrors, standard radio, climate controls, smoking/lighting, fuel gage, heating/air conditioner, map, and others. For example, using the radio required 1.20 sec of glance time and 3.5 total glances, and reading the map required 1.70 sec of glance time, and 5.0 total glances. Wierwille and Tijerina[37] performed one investigation into this issue that compared exposure levels for in-vehicle devices to number of crashes associated with the use of these devices. Exposure was the number of glances, multiplied by the time for a single glance, multiplied by the frequency of use. When the variety of in-vehicle devices was examined in light of both number of crashes and their exposure, a linear relationship resulted such that the greater the exposure, the greater the number of crashes. This study suggested that the ". . .relative number of accidents is directly related to visual resource allocation for in-vehicle tasks." The data regarding amount of time used for in-vehicle devices reported in this study may be a useful starting point for estimating the maximum amount of time that a driver can attend to a distraction outside the vehicle.

2.6.2 Current Measurement of Distraction

It would be beneficial to measure the effect that EBBs have on driver distraction. Such measures for EBBs and other stimuli external to the vehicle have not yet been developed. However, there is one approach being developed for in-vehicle information systems that, with some refinement, may serve as a measure of EBB distraction.

Olsson and Burns[38] describe a peripheral detection task (PDT) that is designed to measure visual distraction and driver mental workload. This study included measures of reaction time and correct detection rate for drivers who were asked to report the presence of an LED dot shown briefly at slightly different locations on a windshield while: 1) driving on country roads and a motorway and 2) performing a secondary task while driving. The dots were projected 11-23 degrees to the left of the straight-ahead view and 2-4 degrees above the horizon. This location approximates the visual angle that corresponds to a pedestrian or some roadside signs.

Statistically significant results indicated that a CD manipulation task and a backwards counting task required a longer performance time and resulted in fewer correct detections than the baseline driving task. Since these drivers missed more targets when performing a secondary task and because it took longer to report the targets that were spotted, the PDT may be useful in assessing the distractibility of in-vehicle systems. The authors briefly discuss the necessity of defining a criterion such as a percentage correct detection rate and/or reaction time that would define driver distraction.

If the PDT can be applied to in-vehicle systems, it may also be applicable to stimuli external to the vehicle such as EBB and tri-vision signs. It would be necessary to adapt the methodology from an in-vehicle task to a vehicle-external stimulus and to define a criterion for distraction. The PDT procedure might also be employed in addition to the driver performance measures described above, i.e., measures of lateral deviation and speed selection.